CLAIMS

What is claimed is:

1. An apparatus for generating a three-dimensional (3-D) image of a scene illuminated by a light source, comprising:
   (a) a two-dimensional (2-D) array of photodetectors for receiving reflected or scattered light from the scene illuminated by the light source with the light being imaged onto the 2-D array of photodetectors, and with each photodetector in the 2-D array generating therefrom an electrical output signal;
   (b) a plurality of modulators associated with each photodetector in the 2-D array, each modulator receiving the electrical output signal from that photodetector and an alternating current (ac) reference signal with a different phase delay for each modulator, and generating a modulated output signal from each modulator associated with that photodetector;
   (c) a plurality of integrators associated with each photodetector, each integrator receiving the modulated output signal from one of the plurality of modulators, and generating therefrom an integrator output signal for each integrator associated with that photodetector; and
   (d) a computational unit receiving each integrator output signal associated with each photodetector and generating therefrom intensity and range information about the scene illuminated by the light source to generate the 3-D image of the scene.
2. The apparatus of Claim 1 further including an optical element located proximate to the 2-D array of photodetectors to image the reflected or scattered light thereon.
3. The apparatus of Claim 1 wherein the 3-D image of the scene is generated in response to a single pulse of light from the light source.
4. The apparatus of Claim 1 wherein the light source comprises a laser or a light-emitting diode.
5. The apparatus of Claim 1 wherein the 2-D array of photodetectors is located on a first substrate, and the plurality of modulators is located on a second substrate.
6. The apparatus of Claim 5 wherein the first and second substrates are superposed one above the other and electrically connected together.

7. The apparatus of Claim 6 wherein the first and second substrates are electrically connected together by a plurality of solder bump bonds.
8. The apparatus of Claim 1 wherein each photodetector comprises a silicon photodetector.
9. The apparatus of Claim 1 wherein each photodetector comprises an indium gallium arsenide (InGaAs) photodetector.
10. The apparatus of Claim 1 wherein each photodetector comprises a mercury cadmium telluride (HgCdTe) photodetector.
11. The apparatus of Claim 1 wherein the electrical output signal from each photodetector is filtered or amplified or both prior to being provided to each modulator associated with that photodetector.
12. The apparatus of Claim 1 wherein the phase delay for each modulator associated with one of the photodetectors comprises an integer fraction of a period of the ac reference signal.
13. The apparatus of Claim 1 wherein the phase delay for one of the plurality of modulators associated with each photodetector is 0 degrees, and the phase delay for the remainder of the plurality of modulators associated with that photodetector comprises an integer multiple of 360/n degrees where n is a total number of modulators associated with that photodetector.
14. The apparatus of Claim 1 wherein the plurality of integrators associated with each photodetector in the 2-D array comprises three integrators.
15. The apparatus of Claim 14 wherein the phase delay for a first integrator of the three integrators is 0 degrees, the phase delay for a second integrator of the three integrators is 120 degrees, and the phase delay for a third integrator of the three integrators is 240 degrees.

16. A method for generating a three-dimensional (3-D) image information from a scene illuminated by a light source, comprising steps for:
    (a) detecting reflected or scattered light from the scene illuminated by the light source with a two-dimensional (2-D) array of photodetectors and generating an electrical output signal from each photodetector;
    (b) simultaneously modulating the electrical output signal from each photodetector by a plurality of modulators operating at the same reference frequency, but with a different phase delay for each modulator, and thereby generating a plurality of modulated output signals for each photodetector; and
    (c) separately integrating each of the plurality of modulated output signals for each photodetector and producing therefrom a plurality of integrator output signals wherefrom intensity and range information for each photodetector can be determined.
17. The method of Claim 16 further comprising a step for imaging the reflected or scattered light from the scene onto the 2-D array of photodetectors with an optical element.
18. The method of Claim 16 wherein the step for detecting the reflected or scattered light from the scene comprises detecting the reflected or scattered light from a single pulse of light from the light source.
19. The method of Claim 16 wherein the light source comprises a laser or a light-emitting diode.
20. The method of Claim 16 wherein the step for generating the electrical output signal from each photodetector comprises transforming a photocurrent signal generated by the photodetector in response to detected light into a voltage signal.
21. The method of Claim 20 wherein the step for generating the electrical output signal from each photodetector further comprises amplifying or filtering the photocurrent signal or the voltage signal.
22. The method of Claim 16 wherein the phase delay for each modulator comprises an integer fraction of a period of the reference frequency, or a multiple thereof.

23. A three-dimensional (3-D) imaging camera for generating a 3-D image of a scene illuminated by a single pulse of light from a source, comprising:

(a) a two-dimensional (2-D) array of photodetectors, with each photodetector in the array receiving reflected or scattered light from the illuminated scene and generating therefrom a photodetector output signal;

(b) at least two modulators receiving the photodetector output signal from each photodetector and generating a modulator output signal which is a product of the photodetector output signal and an alternating current (ac) reference signal, with the ac reference signal for each modulator having the same frequency and a different phase delay;

(c) an integrator connected to receive the modulator output signal from each modulator and to generate therefrom an integrator output signal by integrating the modulator output signal over time; and

(d) a computational unit for receiving each integrator output signal and generating therefrom the 3-D image of the scene.

24. The 3-D imaging camera of Claim 23 wherein the light source comprises a laser or a light-emitting diode.

25. The 3-D imaging camera of Claim 23 further comprising an optical element for imaging the reflected or scattered light from the illuminated scene onto the 2-D array of photodetectors.

26. The 3-D imaging camera of Claim 23 wherein the phase delay for one of the modulators is 0 degrees, and the phase delay for the remaining modulators is equal to an integer multiple of 360/n degrees where n is a total number of the modulators associated with each photodetector.